Age structure and dynamics of *Zoysia japonica* module population

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Abstract: The age structure of the natural *Zoysia japonica* clonal population at Qipan Mountain in Huishan Scenic Spot of Shenyang, Liaoning Province, China was studied using the morphological method in 2003 and 2004. The dynamics of leaves were recorded and the dynamics of tiller and rhizome in the growing season were observed. The results indicated that the rhizomes formed in different years changed in color and rigidity. Its internodes produced in autumn became shorter. The number of naked nodes changed with the tiller age. Rhizome and tiller characters were used as a foundation for judging the ages of modules in this study. The longevity of tiller and rhizome was 3 years at most. At the beginning of the growing season, 2-year-old tillers and rhizomes predominated. Then 1-year-old tillers and rhizomes increased rapidly and became dominant in July. The proportion of buds to tillers on quantity was stable at about 30% in the mid-phase of the growing season and rose to about 50% in autumn. The seasonal dynamics of tiller, rhizome and bud was very important to guarantee the sustained existence of the *Zoysia japonica* population. The turnover of modules was the mechanism of sustaining the rejuvenation of the *Zoysia japonica* clonal population.

Keywords: *Zoysia japonica*; Module; Age structure; Dynamics

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Introduction

Age structure is a very important parameter in understanding the status and the future tendency of a population. Clonal plants could thrive in favorable habitats and live stably in some areas for centuries. A clone's life has no physiological limit because new ramets could be produced constantly (Silvertown Jw 1987). The study of age structure could help us to understand the secret of longevity of clonal plants and tiller propagation schedule. Two methods are generally used to study the age structure of clonal plants. One is generational method (Yang 1995, 1998, 2001, 2003) and the other is dependent on the real living time according to morphological characters with age (Liu 1995; Bai 1999; Li 2000; Zhang 2004).

Japanese Lawngrass *(Zoysia japonica)* is a typical rhizomatous clonal herb. Because of its economic and ecological value, Japanese Lawngrass has been widely studied. Wang (2003) studied the age structure of Japanese Lawngrass by the generational method and obtained some valuable conclusion, but the result did not give us a seasonal dynamics of the modules. According to the generational method, the first generation tillers are those firstly develop upwards from buds on the nodes of rhizome and secondary generation tillers develop from the buds of first generation tillers (Yang 1998a). However, Japanese Lawngrass in a community with high coverage seldom produces the tillers of secondary generation, and most of the tillers develop directly from the buds on the nodes of rhizomes. Thus it had been concluded that the first age-class tillers predominated with a proportion over 95% in each month during the whole growing seasons (Wang 2003).

In this study, a natural population of Japanese Lawngrass with the coverage over 90% was studied by the real living time method, with the purpose to reveal the seasonal dynamics of Japanese Lawngrass population further and give some useful reference to age structure research of clonal herbs.

Study area and methods

The study was conducted at Qipan Mountain in Huishan Scenic Spot (123°E, 41°36'- 41°57'N), Shenyang, China, The elevation is 100–266 m above sea level. The extreme temperature of this area is -33.1 ℃ in winter and 38.3℃ in summer, annual average temperature is 7.8℃, and the annual average precipitation is around 705.4 mm (mainly in July and August). The frost-free period is about 125 d. The sum of heat above 10 ℃ is 3 376.6 day degree.

For observation of the modular characteristics of Japanese Lawngrass, 50 tillers were chosen at the beginning of the growing season in 2003 and the birth and death dynamic of the tiller leaves were observed during the whole growing season. At the same time rhizome characteristics including node length, color, and rigidity were recorded.

Three sample units of 25 cm×25 cm were set to study the age structure of Japanese Lawngrass and observation was made every month from April to September in 2004.

Data disposal, the quantity indexes in the area of 25 cm×25 cm were transformed to those in the area of 1 m×1 m. Age structure is expressed by M±SD, where M is the mean value of 3 samples, and SD is the standard variation among samples. The age structure is also expressed by the specific value of the quantity of each age ingredients to the total quantity.

Results and analysis

Birth and death dynamics of tiller leaf in growing season

Birth of leaf: The growth of Japanese Lawngrass began at the end of April. It leafed out one blade every 11 days before

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mid-June and the leaf number per tiller increased to 4 within the first 45 days (Fig. 1). After that, the leaf emergence speed decreased to 1 leaf every 15 days until August. At the end of August each tiller produced 9 leaves totally on average. Generally, no new leaf developed in September. Some tillers could produce 10 leaves per year at most and the last leaf produced at the end of September usually was a juvenile leaf that could not outspread enough.

Death of leaf: A leaf has its own life span just as a living organism. In general, leaves of Japanese Lawngrass could live more than 1 month. The dead sequence of leaf was from underside to upside of a tiller. The death process of a tiller leaf was as follows according to our observation. No leaves died before mid-June (Fig. 1), 1 leaf died per month from June to July, after that, death speed of leaf increased, two leaves died in August and 3 leaves died in September.

The birth and death of the leaves kept a dynamic balance and a mature tiller always had 4 to 5 living leaves in the mid-phase of the growing season. Leaf death speeded up and the speed of leaf emergence decreased in the later phase of the growing season. At the end of September, only 3 leaves with yellow tips existed on a tiller. In October, all leaves turned to yellow and the tillers came into dormancy ultimately.

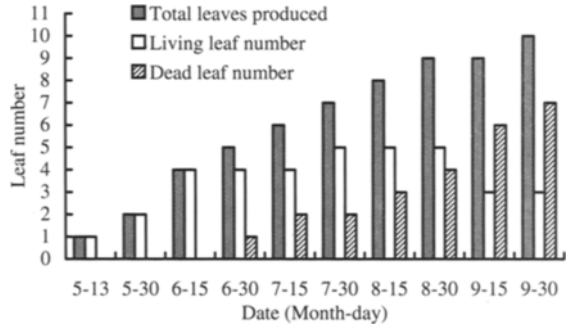

Fig. 1 Birth and death processes of leaf of *Zoysia japonica* tiller per year (means of 50 tillers)

Judgment of tiller age

Judgment of the real living time of the tillers is complicated because the development of tillers from buds can occurs continually in a growing season and most tillers could live more than one year. According the observation in the field we found that a tiller had dense nodes at its basal part near the ground. Each node could only produce 1 leaf. After a leaf died and shed from a tiller the node that it had lived on became exposed. The total exposed node numbers could give us a clue as to how many leaves had been shed from the tiller. So the numbers of surviving leaves and exposed nodes were very valuable to judge the tiller age consulting to the dynamics of leaves in each month (Fig.1). But we should subtract 4 from the total exposed node number to get the shed leaf number, because when a tiller bourgeoned from a bud there were 4 bud scales outside each bud of Japanese Lawngrass and 4 exposed nodes were left after the 4 bud scale had been shed.

In this research the tillers formed in any month of the same year were regard as the same age. Thus tillers formed in this year were regarded as 1- year-old tillers and those formed in last year were regarded as the 2-year-old tillers. A 3-year-old tiller which bourgeoned from a bud in April of the year before last year could produce about 30 leaves in total. The judging method of the tiller age was listed in Table 1.

Table 1. The evaluating standard for the tiller ages of *Zoysia japonica* by total leaf number per tiller

The end of each month	Tiller ages		
	One year	Two years	Three years
April	1 leaf and no dead leaf	Dead leaf existed, 1<total leaf number≤11	Total leaf number>11
May	2 leaves and no dead leaf	Dead leaf existed, 2<total leaf number≤12	Total leaf number>12
June	Total leaf number≤5,1dead leaf	5<total leaf number≤15	Total leaf number>15
July	Total leaf number≤7, 2dead leaf	7<total leaf number ≤17	Total leaf number>17
August	Total leaf number≤9, dead leaf≤3	9<total leaf number≤19	Total leaf number>19
September	Total leaf number≤10, dead leaf≤6	10<total leaf number≤29	Total leaf number>29

Note: Because the bud scales number = 4, so the total leaf number produced per tiller = (exposed node number – 4)+ existing leaf number.

If the exposed node number was smaller than 4 the item of 'exposed node number - 4' =0 because no leaf had been shed from the tiller.

Age structure dynamics of tiller in growing season

According to the method above we obtained the age structure of Japanese Lawngrass tillers (shown in Table 2). The total number of tiller increased constantly from April to August. In September the tiller number decreased.

Table 2. Quantity dynamics of different age tiller of *Zoysia japonica* in each month ((X±SD)/m²)

Date	1-year-old tiller	2-year-old tiller	3-year-old tiller	Total number
28-April	561.0±23.5	5089.0±151.0	86.0±19.2	5735.7
28-May	2510.3±185.7	4189.3±164.1	21.0±3.6	6720.7
28-June	7477.3±287.9	1867.7±587.5	16.3±8.1	9361.3
28-July	7926.0±100.4	1295.7±281.9	0	9221.7
28-August	8769.0±277.0	1147.0±248.2	0	9916.0
28-September	7417.0±271.1	437.3±72.7	0	7854.3

Tillers of Japanese Lawngrass had an obvious dynamics of age structure in the whole growing season (Fig. 2). At the beginning of the growing season, 2-year-old tillers predominated, with a percentage of 88.7, due to the fact that many tillers produced in the previous year could overcome winter by dormancy. Then 2-year-old tillers died gradually in the following months. From April to June, the percentage of 2-year-old tillers decreased rapidly, and at the end of September, it decreased to 5.6%. Contrarily, 1-year-old tillers had a reverse dynamic tendency. At the beginning of the growing season, the percentage of 1-year-old tillers was 9.8% and its percentage increased rapidly until the end of June. At the end of September, 1-year-old tillers held a dominant position in the population with a percentage of 94.4. The continuous increase of 1-year-old tiller depended on the sustaining output of 1-year-old tiller from the bud pool.

The 3-year-old tillers only had a small proportion in the popu-

lation, which meant that very few tillers could live to the third growing season. At the end of April, 3-year-old tillers accounted for 1.5%. According to the result in this study, 3-year-old tiller vanished at the end of July (Fig.2 and Table 2).

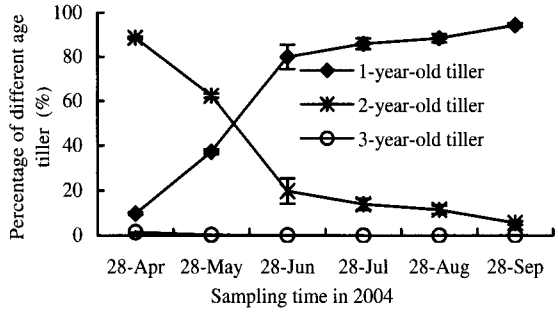

Fig. 2 Dynamic percentage of different age tillers of *Zoysia japonica* population in growing season

Age structure dynamics of rhizomes

Japanese Lawngrass is a rhizomous herb. Rhizomes cross and lap over each other just like a thick matting. Vegetative propagation was dominant in Japanese Lawngrass population. Rhizomes are the nutrient pool and a main propagative organ of Japanese Lawngrass, with many nodes and internodes. As a rhizome grow, new buds and tillers come out from its nodes. There is a bud at the tip of the rhizome that grows and produces new nodes and internodes constantly in the growing season. With the new parts of rhizomes growing, the older parts of rhizomes die gradually.

According to our observation, three criteria were used comprehensively in this study to judge the age of rhizomes. Firstly, rhizome age can be judged by the age of the oldest tiller inserted on it because some tillers grow up with the rhizomes in the same growing season. Secondly, the length of each internode had a seasonal dynamic according our observation. As autumn came, the internode length became shorter than those produced in summer. This character helped us judging the turning point of a rhizome between two years. Thirdly, rhizome color changed with age. 1-year-old rhizome was hard and fresh, white with some yellow in color. Newly formed nodes had intact bud scales. The 2-year-old rhizome was darker than 1-year-old one and most bud scales on the nodes shed. The 3-year-old rhizome was hollow and became gray.

The length of rhizomes with different ages was counted according to the criteria listed above. In the whole growing season the rhizomes showed a similar dynamic as tillers (Fig.3). Two-year-old rhizomes predominated at the beginning of the growing season in April and then died rapidly from April to July. At the end of September, 2-year-old rhizomes comprised 20.7% of the total. Most 2-year-old rhizomes died in the following winter and the 3-year-old rhizomes in spring only accounted for 1.1%. Three-year-old rhizomes disappeared from the samples of July. The percentage of 1-year-old rhizomes increased rapidly from 0 in April to 76.5 at the end of July. One-year-old rhizomes predominated at the end of September, with a percentage of 79.3.

Bud number dynamics in the growing season

The bud pool is very important to maintaining the sustainable survivorship of Japanese Lawngrass population, and buds are the potential population of the plant species. We only counted the bud number and did not subdivide the bud age in this study because a majority of bud inserted on the nodes of rhizomes. Monthly bud proportion to tiller numbers is shown in Fig. 4.

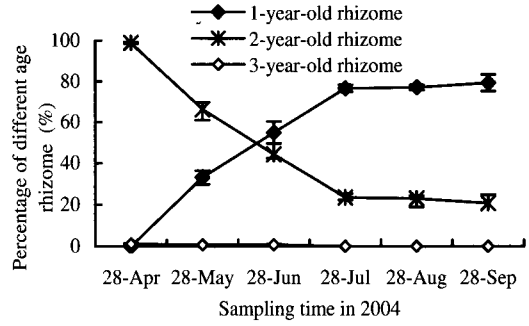

Fig.3 Dynamics of different age rhizome in *Zoysia japonica* clonal population

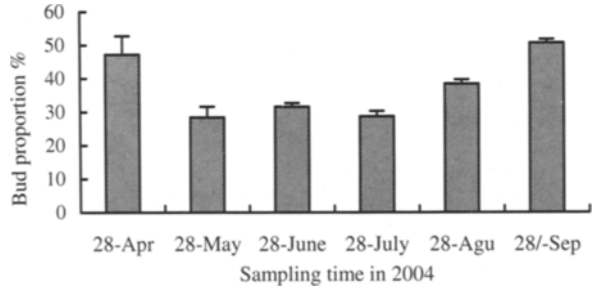

Fig. 4 Bud proportion to tiller numbers each month in 2004

Note: bud proportion= bud number/tiller number in the same sample

At the beginning of the growing season, the bud proportion was 47.2% in the population. As the buds bourgeoned to 1-year-old tillers, bud proportion decreased and maintained about 30% in the following months until autumn. New buds recruited the bud pool, and new tillers formed from buds continuously in the whole growing season. At the end of September, the bud proportion increased to 50.7% and these buds guaranteed the tiller numbers in the next spring.

Conclusion

The age for the oldest tiller and rhizome of Japanese Lawngrass is 3. In spring 2-year-old tillers and rhizomes predominated, but their proportions decreased in the following months. The proportions of 1-year-old tillers and rhizomes increased and held dominant position gradually at the end of July. There was a fluctuating balance between 1-year-old and 2-year-old modules of Japanese Lawngrass. Bud proportion to tiller was high in the population at the beginning and end of the growing season. Bud proportion maintained stably at 30% in the mid-phase of the growing season.

The dynamics of bud, tiller and rhizomes in the growing season was an effective strategy to guarantee the sustaining existence of the Japanese Lawngrass population.

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